EMISSION CHARACTERISTIC OF HYDRATION GAS IN CEMENT MORTAR USING DIFFERENT CHEMICAL ADMIXTURES

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Introduction

Indoor air pollution problem is the primary concern in modern society because most people spend approximately 90% of their life in indoors[1]. According to the technical report of US Department of Energy, indoor air pollution has been closely associated with some diseases such as allergy and asthma as well as with fatigue, headache, cough, rhinitis, sore throat, skin irritation[2, 3].

On the other hand, there are some research concerning emission of harmful gases from cement concrete in Japan recently and they have reported that indoor air can be contaminated by harmful gases, which released from hydration process of cement concrete (mortar)[4]. The amount and type of the gases may depend on the composite conditions of concrete, especially the addition of admixture materials such as chemical agents which is being widely used in normal concrete. The gases can be significantly influenced the health of residents who live in such spaces or workers who are working in a sealed space surrounded by cement concrete on a construction site.

The focus of this paper is to investigate the emission characteristic and type of hydration gas emitted from cement concrete using the different type of chemical admixtures.

Materials and methods

Table 1 shows the chemical component of four chemical admixtures. And In this study, the specimens were prepared using four different chemical admixtures, i.e. polycarboxilic and lignin, naphthalene, melamine type as shown in Table 2. These chemical admixtures are generally used in manufacturing normal concrete. The addition ratio of chemical admixture was 0.01% by cement weight in all specimens. Ordinary Portland Cement (OPC) as specified in KS L 5201 and river sand less than 0.5mm were used. Water-to-cement ratio (W/C) was fixed at 0.55 and cement-to-sand ratio was 2.45. , All specimens were cast into a mold of dimensions 150×150×50mm for analyzing the emission of gas and placed into the environmental chamber. The environmental chamber was then immediately sealed and cured for 24 hours in a constant temperature and humidity chamber at 20±2℃.

Table 1 Chemical component of chemical admixtures (solution) by GC/MS

Polycarboxilic Type		Lignin Type		Naphthalene Type		Melamine Type	
R. Time	components	R. Time	components	R. Time	components	R. Time	components
2.54	1,4-dioxane	3.96	2-Furanmethanol	3.96	2-Furanmethanol	-	-
3.49	Cyclotrisiloxane	6.37	Decane	4.85	Ethanone, 1-	6.38	Decane
6.36	Decane	7.90	Benzene, 1-ethyl-3,5-dimethyl-	6.38	Decane	7.82	Benzaldehyde, 4-methyl-
7.79	Benzaldehyde, 4-methyl	8.42	1,3-Cyclopentadiene	7.90	Benzene, 2-ethyl-1,4-demethyl-	7.90	Benzene, 1-ethyl-3,5-dimethyl-

7.88	Benzene, 1-methyl-3-	8.49	Benzene, 1,2,3,4-tetramethyl	8.42	Benzene, 1,2,3,4-tetramethyl	8.42	Benzene, 1,2,3,4-tetramethyl-
8.41	Benzene, 1,2,3,4-tetramethyl	9.02	Mentha-1,4,8-triene	8.50	Benzene, 1,2,4,5-tetramethyl	8.50	Benzene, 1,2,3,5-tetramethyl-
9.54	Naphthalene	9.56	Naphthalene	9.56	Naphthalene	9.56	Naphthalene
-	-	-	-	9.69	Dodecane	-	-
-	-	-	-	10.36	Isoquinoline	-	-
13.04	Ethanone, 1,1'-	-	-	13.05	Ethanone, 1-	13.0	Ethanone, 1,1'

Table 2 Types of cement mortar

Marks	Type of Specimens
M0	Normal Mortar (without agent)
M1	Normal Mortar + Polycarboxilic type agent
M2	Normal Mortar + Lignin type agent
M3	Normal Mortar + Naphthalene type agent
M4	Normal Mortar + Melamine type agent

In this study, the environmental chamber sampling system was especially designed, and consists mainly of a 0.02m^3 stainless steel environmental chamber and gas sampling system as shown in Fig. 1. Sampling of gases was performed by collecting the gases directly in a tedler bag using an MFC pump for gases released from cement mortar within the early hydration stage of 24 hours.

A SHMADZU-2010 gas chromatogram coupled to a SHMADZU-QP2010 Mass selective detctor was used in electron ionization mode at 70eV with helium as carrier gas. The column was a 30m long DB-5MS with 0.25mmI.D. and 0.25um thick film. Mass scan rage was 35 to 300 at a rate of three scans per second. Analytes were desorbed from the SPME fiber for 30 s into the injector, which was operated in splitless mode at 220℃.

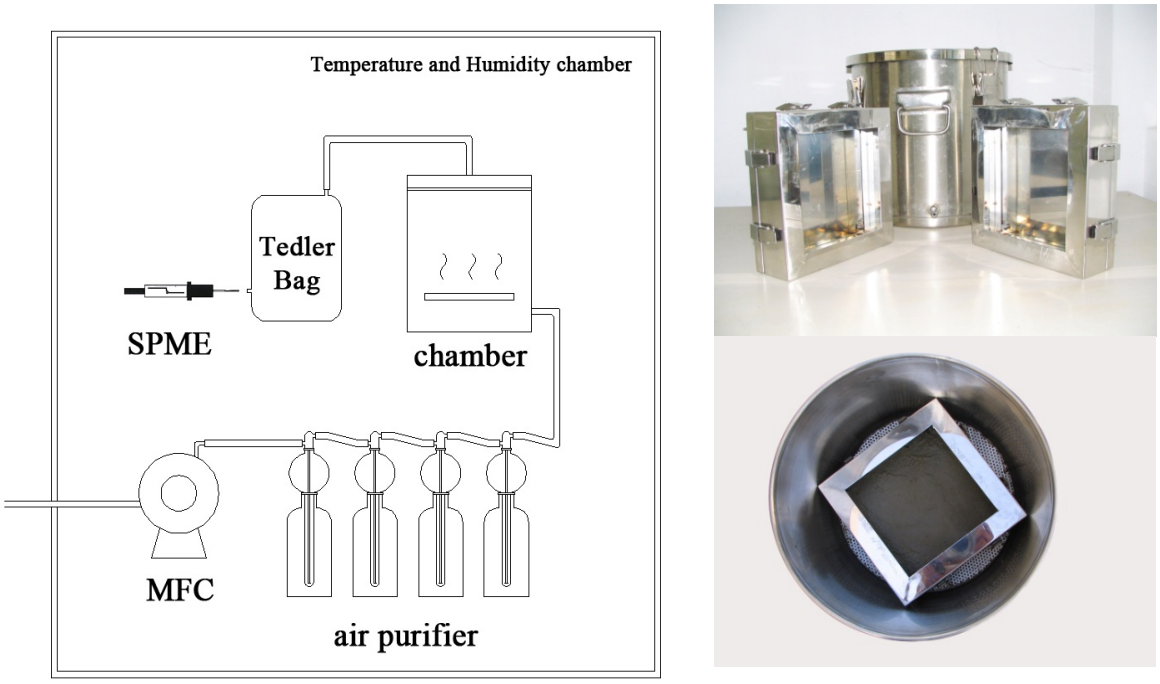

Fig. 1 Gas sampling system and placing mortar into the environmental chamber

Results and discussion

In this study, the emission of hydration gas from cement mortare was investigated using SPME-GC/MS. Table 3 shows the common chemical components of hytration gas released from all type of mortar (M0-M4) cured for 24 hour in the environmental chamber. The result has clearly shown that the various gases were released by hydration process of cement concrete (mortar).

Table 3 Hydration gas peak list detected from cement mortar (M0-M4).

Chemical components
Toluene, o-ethyl-; BENZENE, 1,2,4-Trimethyl-; Decane; 4-METHYLDECANE; 1-HEXANOL, 2-ETHYL-; Benzene, 1-methyl-3-propyl-; Nonane, 2,5-dimethyl-;2-METHYLDECANE; Nonane; o-Xylene, 3-ethyl-; Benzene, 1-methyl-2-(1-methylenthyl)-; p-Xylene, 2-ethyl-; UNDECANE; NONANAL; Benzene, (1,1-dimethylpropyl)-; o-Xylene, 4-ethyl-; TETRADECANE; DODECANE; Cyclohexasiloxane

Table 4 Hydration gas peak list (accept common components - Table 3) detected from cement mortars using four different types of chemical admixture

M1		M2		M3		M4	
R. Time	Components	R. Time	Components	R. Time	Components	R. Time	Components
8.990	Naphthalene, 1,4,4a,5,6,7-hexahydro-2-methyl-	4.085	2-HEPANONE	10.405	1-Azanaphthalene	8.870	6-METHYLUNDECANE
9.055	1-SEC-BUTYL-						

Especially, according to this experimental result, the harmful gases such as Naphthalene and 1-Azanaphthalene can be released to indoor-outdoor environment through diffusion in cement concrete (mortar) and have resulted in the increasing indoor or outdoor air pollution.

Exposure to large amounts of naphthalene may damage or destroy red blood cells. Humans, in particular children, have developed this condition, known as hemolytic anemia, after ingesting mothballs or deodorant blocks containing naphthalene. Symptoms include fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may also cause confusion, nausea, vomiting, diarrhea, blood in the urine, and jaundice (yellow coloration of the skin)[5].

The gases can be significantly influenced the health of workers who are working in a sealed space surrounded by cement concrete on a construction site. Before these chemical admixtures are put into concrete, there are pre-treatments to ensure that admixture characteristics remain constant and it will not cause adverse effects to the cement produced or to the environment.

Acknowledgements

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2007-0055805)

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